

# **RIVALE: A PROTOTYPE REALISTIC IMMERSIVE VIRTUAL AGENT-BASED LEARNING ENVIRONMENT CASE STUDY FOR LEARNING REQUIREMENTS ELICITATION SKILLS**

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## **ABSTRACT:**

Current ways of teaching requirements analysis, such as paper-based case studies, do not sufficiently support development of skills to investigate a problem situation. This paper reports on research to develop and evaluate an initial prototype of a Realistic Immersive Virtual Agent-based Learning Environment (RIVALE) virtual case study. The example fictional case study in this paper would be used as an exercise for students taking a systems analysis and design class to practice and learn requirements elicitation skills, such as interviewing, questionnaires, document review, form review, and observation. The intention is to provide a more realistic experience and to thereby support better learning as well as more realistic assessment of and feedback concerning student skills in requirements elicitation. The requirements, design, implementation, and initial, lightweight evaluation of the initial prototype are described. The initial prototype shows promise, but specific issues, especially problems with achieving realistic conversation, are identified and recommendations for further research are provided.

**Keywords:** eLearning, 3D virtual world, virtual learning environment, immersive learning environment, training, educational case study, virtual agent, virtual case study

## **I. INTRODUCTION**

Students taking an introductory Systems Analysis and Design (SAD) unit/course need to learn requirements elicitation skills. Requirements elicitation (or requirements gathering) is a key systems analysis and design activity in which various techniques, such as interviewing, questionnaires, document review, form review, and observation, are employed to identify the requirements for a new or revised information system. In order to learn these skills well, students need to practice them and develop the ability to judge when and how to use each of them. In teaching them, it is also important

to evaluate how well the students have developed these skills in order to give them feedback to further their learning (formative assessment) and give a final grade or mark (summative assessment).

There are different ways of teaching and learning requirements elicitation skills, including preparing requirements elicitation plans based on written case studies, mock interviews with staff playing roles in class or outside of class, live projects with real clients, and simulations (e.g. multimedia) of case study situations. Each of these are effective to varying degrees and in varying ways at enabling student learning and have their own advantages, but also each have significant disadvantages. Some of the authors have tried all of these techniques. Based on our experiences, disadvantages found among some of these extant approaches include insufficient realism to authentically practice the skills needed for requirements elicitation, lack of coverage of different requirements elicitation techniques, some students get to practise skills while others don't, high cost and lack of staff time (e.g. for multiple simulated/mock interviews), high cost and lack of availability of real clients, low engagement (e.g. of a paper-based case study) to motivate students to learn, and use of resources (e.g. staff or real client time) in an inefficient manner that makes them ultimately unsustainable.

To address the above problems with approaches for learning requirements elicitation skills, this paper addresses two research questions:

1. How can we more effectively and efficiently teach requirements elicitation skills?
2. How can we more effectively engage students in learning the full range of requirements elicitation skills?

To help to address the above problems, the authors propose the development of Realistic Immersive Virtual Agent-based Learning Environments (RIVALE), within which one could host more realistic case studies with which students could interact to practice and learn requirements elicitation skills. A RIVALE case study would use a 3D Virtual World (3DVW) to provide a learning space in an immersive environment in a Virtual Learning Environment (VLE) to simulate a case study as realistically as possible. The approach is to replace paper-based case studies (which hand all the answers to students and don't require practicing some requirements elicitation skills) and interviews with people playing roles (which is very labour intensive and somewhat unrealistic) with a RIVALE virtual case study, in which students choose their own course of action and can practice all the different skills of requirements elicitation. The development and evaluation of a RIVALE case study takes a Design Science research approach.

This paper motivates and describes an initial prototype based on the 3DVW Open Wonderland as an initial development toward a full-featured RIVALE virtual case study. It also describes an initial, lightweight evaluation of the prototype and some ideas for further research. The next section reviews existing approaches to teaching requirements elicitation, introduces 3DVWs and VLEs, and reviews relevant literature on virtual agent technologies upon which the prototype case study is based. Section 3 develops requirements for a RIVALE virtual case study. Sections 4 and 5 present the design and implementation of the RIVALE prototype described in this paper. Section 6 presents the results of a lightweight evaluation of the RIVALE prototype. Finally, section 7 discusses the results and proposes further research.

## II. LITERATURE REVIEW

This section introduces topics and terminology and reviews literature relevant to this paper.

### TEACHING REQUIREMENTS ELICITATION

As discussed in the introduction, learning requirements elicitation (or requirements gathering) skills, such as interviewing, questionnaires, document review, form review, and observation, is a key systems analysis and design activity. This section briefly describes various different ways of teaching and learning requirements elicitation skills, each with their own advantages and disadvantages.

Traditionally, to practice, evaluate, and give feedback on elicitation skills, an instructor can give an assignment based on some paper-based case study to ask the student to describe what they would do in that particular situation and to design questionnaires or interview schedules. While this approach covers elicitation skills broadly, writing an interview schedule and actually carrying out an interview are very different things. Therefore, much potential learning about the interviewing task and needed skills does not occur. Moreover, paper case studies are often quite abstract and not very engaging for the students.

Alternatively, one can hold mock interviews during a class session, in which students interview a person playing a role. Other students can observe the mock interviews and learn from what happens. While this approach is engaging and more realistic, not every student may get to actually conduct an interview. Also, it may still not be realistic in that the interview is somewhat fragmented/disjoint and the interviewer may have very little stake in what they find out from the interviewee (meaning that they don't really practice listening to the interviewee). It also does not confront other issues, such as that it may be difficult to arrange and schedule interviews.

A third approach that deals with the previous two issues is role play in that one can have people who can pretend to be people in the case study and be interviewed outside of class time. However, people can become tired of that (particularly if there are a lot of students to interview them) and the workload and concomitant costs may be quite high and ultimately unsustainable.

A fourth approach is to have a live project with a real client, for which students need to have (or obtain) access. As this is the real task, it is very realistic. However, students just learning may waste the client's time, be ineffective, and ultimately disappoint the client, leading to difficulties in obtaining clients willing to take the time to work with students.

The above discussion mostly addresses only interviews and questionnaires, not other elicitation skills. Furthermore, the student does not need to tie together and integrate what they learn from other sources to build up a comprehensive picture of what they needed to find out in order to carry out their systems analysis and design.

Another approach that deals with other skills than interviews is using a simulated environment of some kind. Twenty years ago, Kendall et al [1992] developed a hypermedia-based case study that allowed students to explore a situation to determine requirements. This provided some realism, but compared to today's state of the art in 3D Virtual Worlds (3DVWs) and Virtual Learning Environments (VLEs), the realism was quite poor. In particular, the ability to interview, observe, or conduct questionnaires is quite lacking.

Besides the problems from the teaching efficiency point of view, from the student point of view, approaches such as reading canned case studies and designing interview schedules and a requirements elicitation strategy that will never be carried out are too hypothetical and don't sufficiently engage the students in their own learning. They aren't very memorable and don't have consequences downstream that make learning practically important. Based on the above problems and research gap, we formulated two research questions in the introduction:

1. How can we more effectively and efficiently teach requirements elicitation skills?
2. How can we more effectively engage students in learning the full range of requirements elicitation skills?

What is needed is a way to practice requirements elicitation skills that is both resource efficient and realistic, and in which failure to effectively elicit requirements has consequences for inadequate development of requirements for systems. This paper pursues an approach using realistic immersion with virtual agents in 3DVWs and VLEs, which are introduced in the next three sections.

### **3D VIRTUAL WORLDS (3DVW) AND VIRTUAL LEARNING ENVIRONMENTS (VLE)**

The Australian and New Zealand Virtual Worlds Working Group defines virtual worlds as "computer-based, immersive, [persistent] 3D multi-user environment that simulates real (or imaginary) life, experienced through a graphical representation of the user." Virtual worlds are an environment with basic functionality to create and use scenarios; often without the restrictions from the real world [Bainbridge, 2007]. 3D Virtual Worlds (3DVWs) may not be primarily designed for pedagogical use, but if designed primarily for teaching and learning, they are generically known as Virtual Learning Environments (VLEs).

VLEs are "computer-based environments that are relatively open systems," [Wilson, 1996, p. 8] to support students to achieve access to learning materials. VLEs became significant with the advancement of the Internet to extend the classroom beyond the physical restrictions of rooms and buildings, allowing students to participate, communicate, and access all resources needed to achieve the learning objectives independent of their locations. VLEs are also social spaces to build networks and communities within a (distant) educational context. VLEs established the necessary functionality to administrate and manage the learning resources and collaboration / communication among the participants; yet are restricted in terms of creating and visualising specific scenarios. Hence,

specialised VLEs were introduced to map scenario layers on top of the VLE functionality; often called Virtual Training Environments (VTEs).

Examples of VTEs include Intelligent Pedagogical Agents [Rickel et al., 1998], Game-based Tutoring Systems [Craighead, 2008], and Educational Simulation Environments [Dede et al., 1999]. VTEs are used in different industries, among others surgery training [Hockemeyer et al., 2009; Ahmed et al., 2012], mining industry for mine safety training [Filigenzi et al., 2000], as well as drill rig training simulation, open pit simulation, or underground hazard identification [Kizil, 2003].

VLEs and VTEs demonstrate many advantages, including their capability to take the distance out of distance education, enhance engagement with students learning online, and blend the virtual with the traditional learning approaches from the classroom environment [Dalgarno and Lee, 2010; Wood and Reiners, 2013]. Virtual experiences include areas such as teacher education [Gregory et al., 2011], engineering [Bresciani et al., 2010], health sciences [Thompson and Hagstrom, 2011], logistics and manufacturing [Wriedt et al., 2008], and situations for training purposes [Reiners and Wood, 2013]. Dron et al. [2011] emphasise the flexibility of virtual worlds to be used as a soft technology enabling creativity and orchestration of new phenomena, or as a hard technology with embedded guidance and rules for efficiency, replicability, and elimination of errors. The case study described in this paper resembles a hard technology, where the space is divided in areas with determined functionality and rather explicit learning objectives.

## IMMERSIVE LEARNING ENVIRONMENTS

Immersion is “the subjective impression that one is participating in a comprehensive, realistic experience” [Dede, 2009, p.66]; “the greater the participant’s suspension of disbelief that she or he is ‘inside’ a [...] setting” [Dede, 2009, p.66]; the more immersed they are; e.g., captivating movies, books, or games that so completely enthrall viewers/readers/players that they ignore basic needs for hours. Immersion can be increased by different means; either technology, perception of the user, or experience. Authentic, or ‘true to life’, tasks and activities can further heighten the users’ experience.

Authentic learning is a pedagogical model based on learning occurring within environments replicating practices and actions being found in real-world situations, forcing learners to engage with similarly authentic materials and responses before receiving valuable feedback. Authentic learning focuses on putting the learning into context. While authentic learning is generally based in the real-world and often uses work placement, internship, or practical training [Dalgarno et al., 2013, under review], many educators in the tertiary sector have eschewed truly authentic learning as this can be costly, dangerous for students, and administratively difficult to arrange [Reiners and Wood, 2013]. Learning does not need to occur within the real environment for it to be authentic learning; where the learning occurs is not crucial, but it is instead that the learning must reflect how the knowledge would be used in that real environment [Herrington et al., 2010]. Thus, it becomes clear that using technology does not, in itself, create authentic learning; instead, sensible incorporation of appropriate technologies into carefully designed scenarios means that authentic learning takes place with technology [Herrington et al., 2010].

The case method (or case studies) is a teaching approach to present learners with a real life situation and engage them in problem identification, process understanding, and decision making [Ellet, 2007]. Descriptive case studies enhance the learning material and create the link between theory and practice. However, the design and presentation affect the intensity of immersion; which is about the degree of realism stakeholders experience in virtual learning environments.

## VIRTUAL AGENTS

In addition to the virtual world for the environment, the use of computer-controlled, autonomous characters (called virtual agents, non-player characters, NPCs, chatbots, or bots) can increase the authenticity for the participants. In order to train elicitation skills, the students need to practice repeatedly scenarios with similar properties and receive formative as well as summative feedback. Traditionally, role-plays performed by multiple actors were used to simulate certain situations and behaviours for the purpose of training. Nowadays, real actors are continuously substituted by bots imitating the actor; ideally up to a level where learners are not able to distinguish between the bot and a human role player. The depth of interaction depends on the underlying systems and their capability of interpreting modifications to the environment and approximating the best possible reaction [Wood and Reiners, 2013]. The variety of bots for virtual worlds is from human supported (puppeteered) bots

[Dieker, 2011; TeachLivE, n.d.], communication and interaction [Predinger et al., 2011], up to displaying emotions [Slater and Burden, 2009].

In the prototype presented in this paper, the bots can be interviewed in two different ways. The first is a managed chat or guided interview available in many 3DVWs while the second is a “free” or “open” conversation using a specified knowledge base built using ALICE technology [ALICE, n.d.] and the Pandorabot hosting service [Pandorabots, n.d.].

### III. REQUIREMENTS FOR A VIRTUAL CASE STUDY

The research addresses resource-efficient, realistic student engagement through the development of a RIVALE virtual case study, in which a 3DVW is used to provide a realistic, virtual environment within which a student or group of students can carry out a whole range of requirements elicitation activities, including practicing and developing the ability to use all the elicitation skills described above in an integrated and holistic fashion. Such a 3D virtual case study would (eventually) allow students to do the following tasks.

- Work together with fellow students in a team of developers
- Contact an organisation and develop relationships with people within the organisation
- Interview people individually or in groups
- Survey people with questionnaires
- Observe people engaged in their normal work practices
- Identify and obtain relevant documents and forms for review
- Observe existing systems in use and conduct participant observation

In order to do (parts of) the above, the 3D virtual world will need to make use of virtual agents with some ability to engage in conversation and with which students could interact.

The longer term goal of the research is to develop a very realistic, immersive experience for the students that is comprehensive in its ability to provide learning and experience for students in the whole suite of elicitation skills described above, and possibly others (e.g. participant observation using simulated existing systems).

### REQUIREMENTS FOR THE RIVALE PROTOTYPE

Venable et al. [2012] have suggested that a good approach to minimize risk in Design Science Research is to conduct an ex ante, artificial evaluation. Ex ante evaluation is evaluation of the artefact(s) in an early state, before constructing a full system in order to focus the design before incurring the expense and effort of a full implementation. Artificial evaluation is not naturalistic [Venable, 2006; Venable et al., 2012] in that it doesn't use a real system, isn't used for a real task, and/or isn't used by real users.

The initial RIVALE prototype was not designed to fulfil all the above features. Instead the prototype reported on in this paper concentrates on developing an initial environment around which students can navigate and learn about the case study situation. The prototype will explore feasibility of the use and the usability of the existing virtual agent technology for the purposes of requirements elicitation interviews. The initial prototype was designed to include the following aspects:

- A realistic physical environment (buildings, offices, etc.)
- Features and tools for student use (workspaces, virtual notebook)
- Prototype virtual agents to interview and converse with
- A tutorial on how to use 3D virtual environments and tools provided in the case study

### IV. DESIGN OF THE CAROL'S CORNER STORE VIRTUAL CASE STUDY

This section describes the Carol's Corner Store case study storyline and the main features designed into the RIVALE Carol's Corner Store virtual case study prototype.

#### CASE STUDY STORYLINE

The case study we selected for the initial prototype development is a fictional case study written by one of the authors as a systems analysis and design case study for student requirements documentation, called “Carol's Corner Store”. Carol's Corner Store (henceforth “CCS”) is a small,

family-owned retail store. Carol Chan is business savvy, but traditional without much technical or systems knowledge. Her daughter Susan has a recent business degree and is driving the change. The case study hinges around inventory handling and timely ordering to prevent out of stock conditions on the display shelves.

In addition to CCS, the work context is one of a junior system consultant for a fictional small IT consulting firm called “Barnes and Ignoble Consulting” or BIC. The student is a new hire at BIC, who takes over the duties of someone who had just begun work for CCS, but resigned suddenly. Ray Barnes is the managing director at BIC and gives the work assignment to students. BIC’s receptionist, Aaron Rogers, is a font of knowledge about BIC and its personnel.

## **RIVALE FEATURES**

### **Tutorial Design**

To address issues of student unfamiliarity with VLEs, we decided that when students first enter the RIVALE prototype, they should encounter an online tutorial on how to use its features. This includes how to move about, how to change views, and how to use features of the environment. It also shows the students how to configure their avatars’ appearance in whatever way they would like, which improves student engagement.

### **Environment Design**

Upon completion of the tutorial, students arrive at Barnes and Ignoble Consulting. Students begin in a streetscape outside and then enter the building where BIC is housed. There they can encounter virtual agents for Ray Barnes, Aaron Rogers, and others, as well as avatars of other students in their workgroups (if any, the case could be done individually or in groups). Various resources are available there, such as materials on requirements elicitation, whiteboards for drawing, and so forth. The physical space includes a reception area, an office for Ray Barnes, a library, and a work room/office for student use.

Like the BIC environment, there is a streetscape outside of Carol’s Corner Store. The environment within Carol’s Corner Store features two main rooms – a front room where customers browse display shelves and make purchases and a back inventory store room where goods are stored and deliveries are received through a large delivery door. There is also a truck and deliveryman outside of the delivery door. Carol also has a desk in a corner of the store room, with a computer, filing cabinets, as well as various things posted on the wall, including a list of suppliers and supplier addresses. Carol’s virtual agent can be found in the store room while Susan’s virtual agent can be found in the front area along with a couple of other staff and customers. The deliveryman is also a virtual agent.

### **Virtual Agent Design**

We elected to use text-based virtual agents to avoid problems with voice recognition and simplify our initial prototype.

Carol’s and Susan’s virtual agent chatbots were designed to provide answers to requirements elicitation questions. These were initially designed to answer the suggested requirements elicitation questions, such as those provided by Pierson Requirements Group [PiersonRequirementsGroup, n.d.] and Practical Analyst [PracticalAnalyst, 2009]. To do so, we decided to use the ALICE chatbot technology [ALICE, n.d.] with its free hosting by Pandorabot [Pandorabots, n.d.], as it is designed to answer open-ended questions. Pandorabot’s virtual agent chatbots are available with various knowledge bases (as AIML files) of general or specific knowledge coded into them. For purposes of the prototype, we decided to test one virtual agent (Susan) that included such pre-defined knowledge and one virtual agent (Carol) that did not include such knowledge.

We also decided to test managed chat using available Open Wonderland features for other virtual agents, including Ray Barnes, Aaron Rogers, and other characters encountered by students. Using a managed chat helps ensure that critical information is received by the student. This would also allow us to evaluate and compare the managed chat and open chat (ALICE/Pandorabot) virtual agent technologies and their suitability and implementation in the case study.

### **Other Features and Tools Designed**

One feature designed into the RIVALE prototype is the use of teleportation to move from one location to another in the case study, principally between BIC and Carol’s Corner Store. To do so, the case study makes use of bus stops that automatically teleport to the other location.

A second and very important feature designed into the RIVALE virtual case study is a notebook that students can record anything they see and any conversations that they have. For example, any document that they view can be copied into the notebook and viewed at any time. Similarly, transcripts of conversations with virtual agent chatbots are automatically added to the student's notebook for later reference. Items in the notebooks can also be copied and pasted into documents outside of the RIVALE 3DVLE in order to write assignments, email other students in their team, etc.

## V. PROTOTYPE IMPLEMENTATION

This section gives an overview of the RIVALE CCS prototype as implemented. We focus on the implementation of the physical environment, tutorial, virtual agent chatbot, and other features discussed in the design above.

We chose to implement our first prototype in Open Wonderland (OW) [openwonderland.org]. According to their website, "Open Wonderland is a 100% Java open source toolkit for creating collaborative 3D virtual worlds." [openwonderland.org]. OW offers a variety of "in-world" collaboration and communication tools, and also supports easy integration of external tools and programs, such as the chatbot system we used. The open source aspect is important for us and we use OW for other research, so have useful experience with it.

## TUTORIAL DESIGN

The tutorial was designed to address the possibility of student unfamiliarity with VLEs generally and Open Wonderland in particular. The tutorial area is the first place that students arrive when they enter the implementation of CCS. The tutorial is comprised of several stations with information on how to use Open Wonderland and the features implemented for the virtual case study (teleportation bus stops, interviewing, the online notebook, etc., as described in more detail below). The stations are arranged around a maze so that students have to get used to navigating and moving their avatar to the next station (see the aerial view screenshot in Figure 1). At each station, specific material is presented and students are invited to practice taking various actions. Students are able to save tutorial materials into their notebook for later reference. Once students work through the tutorials and navigate through the tutorial area, they can use a teleport bus station to teleport themselves to arrive at the Barnes and Ignoble Consulting location.

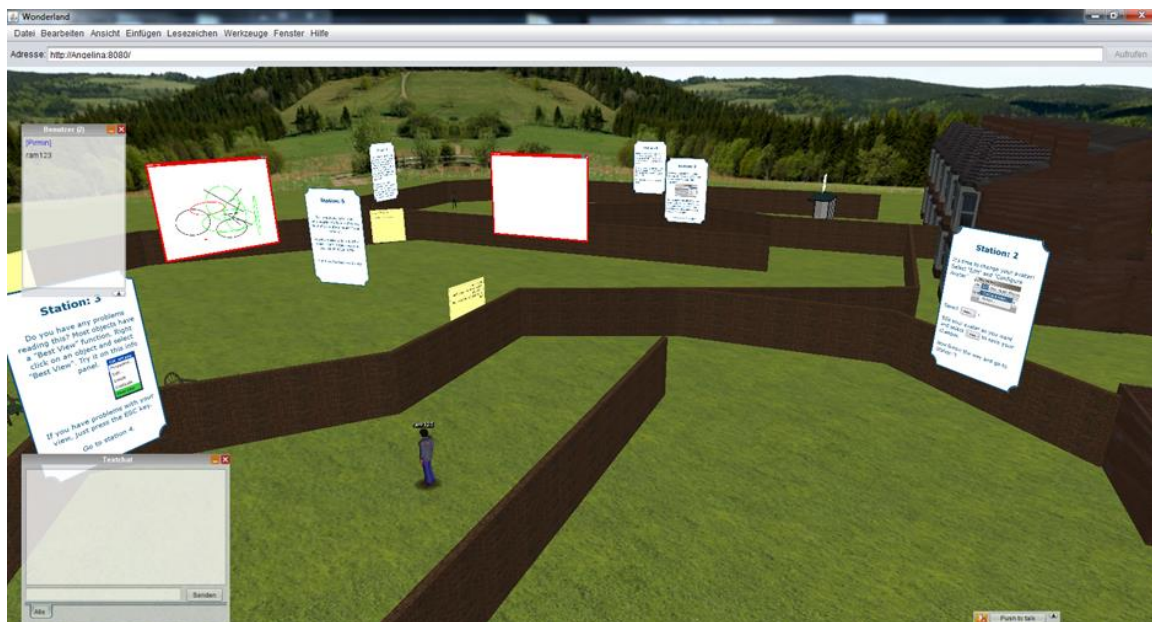


Figure 1: Aerial view of tutorial area

## ENVIRONMENT DESIGN

As noted earlier, the virtual case study per se has two areas, the BIC offices and its local environment and Carol's Corner Store and its local environment. Figures 2 and 3 below show the BIC office area



(with Ray Barnes's office through the door at the back) and the common work area that students can use to meet with other students.

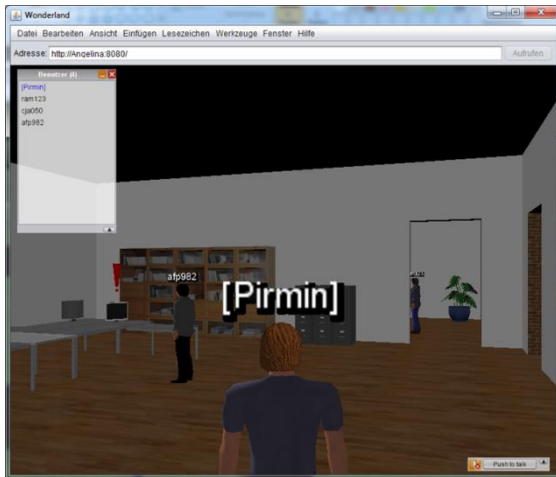


Figure 2: Barnes and Ignoble office area



Figure 3: Barnes and Ignoble meeting area

Figures 4 and 5 below show the Carol's Corner Store area. Figure 4 shows the front, customer area together with a cashier virtual agent behind the counter and Susan Chan's virtual agent toward the back in front of the ice cream display freezer. Figure 5 shows the back store room with Carol Chan's virtual agent in her office area. A list of suppliers is in white on the wall behind her desk.

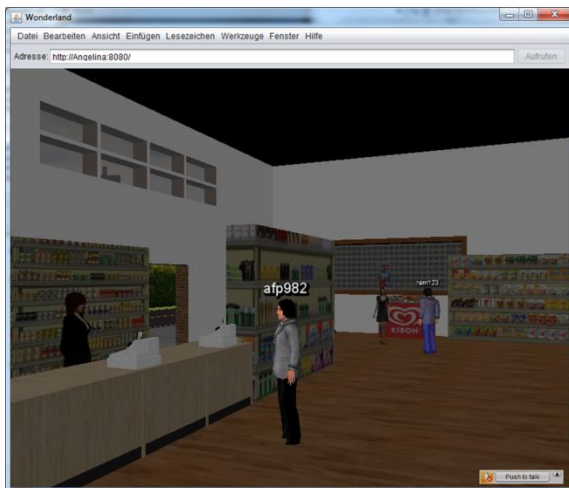


Figure 4: Carol's Corner Store customer area

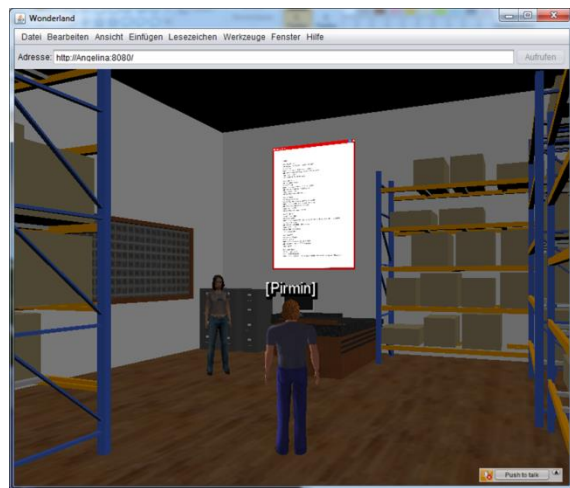


Figure 5: Carol's Corner Store storeroom/office

## VIRTUAL AGENT DESIGN

As described in the design section, we elected to use text-based virtual agent chatbots. Students encounter two kinds of chatbots: those with a structured dialog that guides the student and those with an open ended dialog, in which the student chooses the topic and can ask questions in any fashion. Figures 6 and 7 below show examples of structured dialog and open dialog respectively.



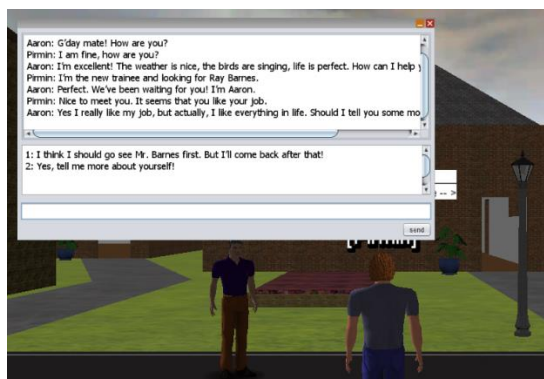


Figure 6: Example guided dialog with Aaron

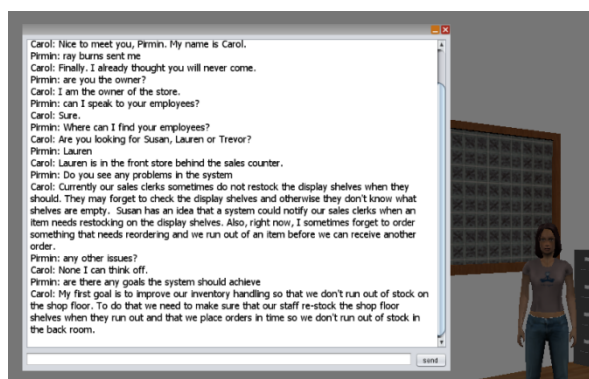


Figure 7: Example open dialog with Carol

The structure, guided dialog, such as shown in Figure 6, is important to guide the student toward necessary information, such as where Ray is located and what tasks need to be performed. In the example, the upper pane shows the dialog so far. The student (Pirmin) has the choice of two responses, numbered 1 and 2 in the lower window. Depending on whether 1 or 2 is typed, Aaron will respond differently. This has the advantage that the dialog never goes off track and the virtual agent never 'misunderstands', but also is limited in what the student can ask.

The open dialog model, such as shown in Figure 7, is more appropriate for students to learn about interviewing skills and requirements elicitation. In this way, students only discover requirements that they seek out and ask for. If they don't ask for information about something, they don't get it and will suffer the consequences in completing their assignment or exercise based on the virtual case study. However, open dialogs have the disadvantage that it is difficult to anticipate all questions that the student might ask and be able to answer unanticipated questions gracefully.

## OTHER FEATURES AND TOOLS DESIGNED

Among the other features designed into the prototype RIVALE virtual case study are the use of teleportation to move between different locations and the development of a virtual notebook that is constantly with students when they are within the Carol's Corner Store virtual case study. Figure 8 shows an example bus stop that teleports a student from the Carol's Corner Store environment to another stop outside of Barnes and Ignoble consulting.



Figure 8: Bus stop teleport to BIC

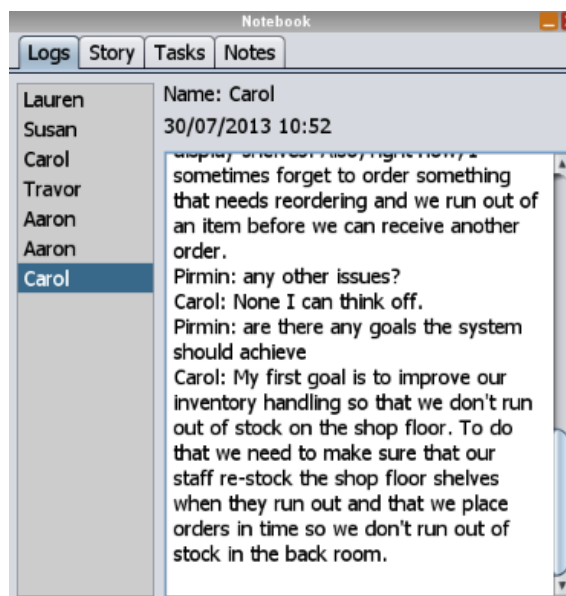


Figure 9: Virtual notebook with dialog with Carol

Figure 9 shows an example of the student virtual notebook, in which the log tab is open to a transcript of an interview with Carol. Along the left you can see the different interview conversations that have been logged into the notebook. Students can easily refer to the notebook, share it with other students, or copy and paste out of it. Across the top you can see there are other tabs for the story (the

assignment), tasks that they have identified or input (perhaps determined in collaboration with other students, and other notes, which can include materials copied from various locations in the case study, such as forms, reports, or the list of suppliers.

Having explored the features implemented in the initial RIVALE prototype for Carol's Corner Store, we now turn to an evaluation of the prototype

## VI. PROTOTYPE EVALUATION

This section describes a lightweight, artificial *ex ante* evaluation of the initial RIVALE CCS prototype. The purpose of this evaluation is to get feedback from potential users of the virtual case study and discover areas in need of improvement as well as suggestions for improving and extending the prototype.

To accomplish the evaluation, we asked experienced teachers of systems analysis and design as well as students who have previously taken systems analysis and design to use the system on an experimental task. Seven participants completed the evaluation. The evaluation was artificial [Venable, 2006; Venable et al., 2012] in that only some of the users are real users, the task was an experimental one rather than real use for teaching and learning elicitation skills, and the system is only a partial (and somewhat rough) prototype.

Evaluation participants were asked to complete a short questionnaire about their experience with 3DVWs before using the system and a comprehensive questionnaire about their experiences with the RIVALE prototype for Carol's Corner Store following the experimental task. The post-task questionnaire had both closed questions to rate specific areas and open questions to provide further information on what they liked and didn't like as well as suggestions for improvement and extension of the prototype. The experimental task consisted of logging in, using the tutorial, exploring both the BIC and the Carol's Corner Store environments, and interviewing the various virtual agent chatbots. Participants also made use of the bus stop teleports and the student virtual notebook.

Table 1 below summarises some of the quantitative findings from the evaluation. The table is divided into four sections corresponding to the overall prototype, the tutorial component, the virtual agent chatbots, and the other features, in that order. The scales of ratings are of agreement with the statements (paraphrased in Table 1), from 1 being strongly disagree to 5 being strongly agree. The average midpoint (for neither agree nor disagree) is then 3. A few questions are phrased negatively (meaning that lower numbers are better), but most are phrased positively. Negatively phrased questions and responses are shown in *italics* below.

As you can see in Table 1, the results are encouraging, but mixed, with areas open for substantial improvement. Complexity and cumbersomeness of the prototype was a concern, but this is perhaps natural for a first-time, two-hour usage; nonetheless, ways to reduce complexity may be useful. It was encouraging that the participants generally found using the prototype to be generally easy and in particular fun and of adequate difficulty. The tutorial was generally easy to use and useful, but could clearly be improved. The virtual agent chatbots were considered important and useful for the case study, but had problems. Both kinds of chatbots were considered useful. Interestingly, the open dialog chatbot that started with the most information built in (Susan) was considered less clever and believable and to provide worse info, even though both provided almost the same answers. The difficulty is in phrasing questions that the chatbot can respond to properly without matching other pre-existing rules. Finally, the teleport bus stop was rated well and the student notebook was rated as useful, but its ease of use could be improved. Possibly improving the tutorial might also improve its ease of use.

The evaluators also provided many open-ended comments and suggestions, which will be very useful for improving the prototype and moving toward a version that can be placed into actual use to improve learning of requirements elicitation skills. However, space limitations prevent discussing them here.

## VII. CONCLUSIONS AND FUTURE RESEARCH

In this section, we discuss the research findings in terms of our original research questions and draw conclusions as well as possibilities for further research.

Table 1: Summary of Selected RIVALE Prototype Quantitative Evaluation Results

Statement or Question	Average	Min	Max	Std Dev
<i>The RIVALE prototype was unnecessarily complex</i>	2.14	1	4	0.99
The RIVALE prototype was easy to use	3.29	2	4	0.70
Others will find the RIVALE case study easy to use	3.86	2	5	0.99
<i>The RIVALE prototype was cumbersome to use</i>	3.14	2	4	0.83
I had fun	4.29	4	5	0.45
I learned new things re. requirements engineering	3.43	2	4	0.73
The difficulty of the tasks was adequate	4.29	4	5	0.45
The tutorial was easy to use	4.00	3	5	0.53
The tutorial had the right amount of information	3.29	2	4	0.70
The tutorial space was useful	4.14	3	5	0.64
I had no more questions after the tutorial	2.86	1	4	1.12
Interacting with chatbots felt like interacting with real humans	2.57	1	4	0.90
Chatbots are important for the RIVALE prototype world	4.29	3	5	0.88
Managed chat (structured/guided chat) was useful	3.43	1	5	1.29
<i>You should remove the managed chat</i>	1.71	1	4	1.16
It was easy to get information from Carol	3.14	2	4	0.64
I had fun with Carol	3.71	3	5	0.70
It was easy to get information from Susan	2.29	1	4	1.03
I had fun with Susan	3.43	2	5	1.05
Which bot was more clever - Carol or Susan?	Carol 5-1			
Which bot gave better info - Carol or Susan?	Carol 5-1			
Which bot was more believable as a human?	Carol 5-1			
I had no problems using teleport bus stops	4.14	2	5	0.99
The logbook (student notebook) was easy to use	3.50	3	4	0.50
The logbook (student notebook) was useful	4.17	3	5	0.69

## CONCLUSIONS

The first research question we asked in the introduction was “How can we more effectively and efficiently teach requirements elicitation skills?”

This paper has proposed that a more realistic, immersive, and interactive virtual world case study could enhance student engagement and improve learning of requirements elicitation skills used in systems analysis and design. To investigate the research questions, the paper presented the design, implementation, and lightweight evaluation of an initial prototype RIVALE virtual case study. Lacking a naturalistic evaluation of RIVALE in real use by real instructors and students, we have only provided evidence based on opinions (of real instructors) about hypothetical student use. Nonetheless, the evaluation of our initial, partial prototype virtual version of the Carol's Corner Store case study has indicated that the approach is promising. However, there are many weak areas that require more work, specifically improving the open dialog virtual agent chatbot performance in realistically answering questions, reducing the complexity of the environment (if possible, although longer term usage and immersion in the case study may improve these ratings, and improving the tutorial.

The second research question we asked in the introduction was “How can we more effectively engage students in learning the full range of requirements elicitation skills?”

This question has been less thoroughly investigated, but we did ask some relevant questions, such as whether participants had fun, which provided encouraging results (but not necessarily convincing ones, since the participants were not real students engaged in study). We have proposed that putting a case study into a VLE, such as RIVALE, will increase student engagement through a more

immersive experience. However, the initial, partial RIVALE prototype was not yet at a sufficient state to evaluate naturalistically [Venable, 2006] by using it in a real teaching and learning situation by real students. Instead, we have only (thus far) been able to ask opinions of teachers and recent students based on the partial prototype. Nonetheless, the evaluators' responses indicate that the work is promising for increasing student engagement in their learning experiences through use of a RIVALE virtual case study once fully implemented.

## FUTURE RESEARCH

Based on our results from the development and evaluation of an initial prototype, we can identify a few promising areas for further research. These include:

- Continue to a full case study implementation of other features including (1) email interface to virtual agents, ability to observe virtual agents at work, and (2) ability to see existing systems being used or even to use them (participant observation).
- Improve virtual agent chatbots with more complete and realistic dialog.
- Improve the tutorial to cover missing areas.
- Introduce more fun aspects of gamification to enhance engagement and learning [Reiners et al., 2012; Wood et al., 2013]. E.g. one could award points for finding out needed information and reduce points for asking questions during interviews that are irrelevant or have already been answered previously.
- Conduct a naturalistic evaluation by students and instructors in (and outside of) the classroom to better evaluate effectiveness and develop better evidence efficient use of staff time and of improved student engagement in learning.

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